Resin-bonded restorations: a strategy for managing anterior tooth loss in adolescence

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Abstract: In children or adolescents with anterior tooth loss, space closure with the patient's own teeth should be considered as the first choice to avoid lifelong restorative needs. Thorough diagnostics and treatment planning are required when autotransplantation or orthodontic space closure is considered. If these options are not indicated and a single tooth implant restoration is considered, implant placement should be postponed until adulthood, particularly in young women and in patients with hyperdivergent skeletal growth pattern. A ceramic resin-bonded fixed dental prosthesis with 1 retainer is an excellent treatment solution for the interim period; it may also serve as a long-term restoration, providing that sound enamel structure is present, sufficient framework dimensions have been provided, adhesive cementation techniques have been meticulously applied, and functional contacts of the cantilever pontic avoided. In contrast, a resin-bonded fixed dental prosthesis with a metal framework and retentive preparation is indicated if the palatal enamel structure is compromised, interocclusal clearance is limited, splinting (such as after orthodontic treatment) is required, or more than 1 tooth has to be replaced.

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Title: Adhesive restorations - Strategy for managing anterior tooth loss in adolescence.

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Resin-bonded restorations: A strategy for managing anterior tooth loss in adolescence

ABSTRACT

In children or adolescents with anterior tooth loss, space closure with the patient's own teeth should be considered as the first choice to avoid life-long restorative needs. Thorough diagnostics and treatment planning are required when autotransplantation or orthodontic space closure is considered. If these options are not indicated and a single tooth implant restoration is considered, implant placement should be postponed until adulthood, particularly in young women and in patients with hyperdivergent skeletal growth pattern. A ceramic resin-bonded fixed dental prosthesis (FDP) with 1 retainer is an excellent treatment solution for the interim period, and may also serve as a long-term restoration providing that sound enamel structure is present, sufficient framework dimensions have been provided, adhesive cementation techniques have been meticulously applied, and functional contacts of the cantilever pontic avoided. In contrast, a resin-bonded FDP with a metal framework and retentive preparation is indicated if the palatal enamel structure is compromised, interocclusal clearance limited, splinting (such as after orthodontic treatment) required, or more than 1 tooth has to be replaced.

INTRODUCTION

Tooth loss in the anterior region requires immediate replacement with an interim or definitive restoration for esthetic and/or functional reasons. Anterior tooth loss, particularly in children or adolescents, usually results from an accident and/or complications from previous trauma (such as external root resorption or ankylosis).[1,2] Maxillary central incisors are the teeth most frequently affected by trauma.[1,2] Because of the potential for complications with implant infraposition, particularly in the maxillary anterior region in young women and in patients with a hyperdivergent growth pattern, single- tooth implants should be postponed until adulthood.[3] During this time, which is particularly critical during puberty, a noninvasive long-term interim restoration should be planned until an implant is indicated. Alternatively, space closure with the patient's own teeth may be considered, which dispenses with repeated treatments throughout the lifetime of the patient. Particularly in children, the potential of autotransplantation of premolars, orthodontic space closure, or resin-bonded fixed dental prostheses (FDP) should be considered.[4,5]

TREATMENT PLAN FOR MANAGING ANTERIOR TOOTH LOSS DURING GROWTH

When a permanent tooth is lost in the mixed dentition during adolescence, a thorough clinical examination should be performed and supplemented by a panoramic radiograph to evaluate potential aplasia. Further, the facial morphology and skeletal situation should be analyzed (orthognathic, prognathic, or retrognathic), and skeletal growth evaluated (normal/ mesocephal, hyperdivergent, or hypodivergent).[5] The form, contour and color of the maxillary incisors and canines should also be analyzed, particularly if orthodontic space closure is considered (Table I).[5-7]

Autotransplantation facilitates the replacement of the missing tooth and the stabilization of the adjacent teeth, and, more importantly, the continuation of the alveolar bone growth accompanied by an enlargement of the gingival tissue volume at the recipient site. High success rates after autotransplantation have been reported, particularly when premolars were transplanted into the area of maxillary incisors (100% after a median of 4.8 years).[8] The ideal time for transplantation is when the root of the selected tooth has reached two thirds to three quarters of the final root length.[9,10] If root development is already complete, endodontic treatment is inevitable and can be initiated before or during the first 2 weeks after transplantation. Keeping the periodontal ligament cells on the root surface vital during the procedure is decisive and can be ensured by careful handling and by storing the extracted tooth in a cell culture medium (Dentosave, Medice; or Save-a-Tooth, Phoenix-Lazerus Inc) (Fig. 1). Following preparation of the recipient site, the transplanted tooth is inserted and splinted for 2 to 4 weeks.[11] Generally, the splinting time depends on the amount of regeneration that has to take place and can be reduced with a perfect fit into the recipient site (for example after tooth avulsion and replacement), but should be increased in case of greater incongruence between the alveolar bone and the root morphology.

If neither autotransplantation nor orthodontic space closure is indicated, the single tooth space must be maintained and movement of the adjacent teeth into the space avoided. Short-term interim restorations can be fabricated chairside by adhesive fixation,[12] or as indirect resin-bonded interim prostheses (Table I).[13] As short-term or long-term interim solutions, resin-bonded restorations provide a minimally invasive treatment option that allows implant placement to be postponed.[3,14,15]

RESIN-BONDED RESTORATIONS

For resin-bonded FDPs, metal or ceramic frameworks have been used and veneered with feldspathic porcelain. Fiber-reinforced composite resin-bonded restorations are potential alternatives but are limited as interim FDP as survival rates were only 73% after 4.5 years.[12] Metal resin-bonded FDPs can be designed with 1 or 2 wings (single- or 2-retainers) and retention at a mesial and/or distal abutment tooth. They can replace 1 or more missing teeth with up to 4 pontics when, for example, the mandibular incisors have to be replaced and the canines serve as abutments (Table II). A retentive preparation facilitates the retention of the metal resin-bonded FDP in addition to the adhesive cementation and may be particularly indicated if the enamel structure on the lingual surface of the abutment tooth is compromised, such as in elderly patients or those with erosive defects. The preparation may be performed with an intraoral parallelometer (Parallel-A-Prep; Dentatus). This involves establishing parallel walls to house the parallel guiding grooves, which facilitate retention and resistance against buccolingual forces, an occlusal/ palatal rest, and sufficient palatal clearance, as well as eliminating undercuts to use the entire enamel surface.[16] To apply the intraoral parallelometer, a diagnostic preparation on a diagnostic cast is recommended to select a similar path of insertion to that planned for the preparation of the parallel guiding grooves (Fig. 2). These grooves should be sufficiently embraced by the metal framework, which is not visible from the labial aspect. The grooves are aligned slightly palatally to miss the incisal edge and avoid metal coverage of the incisal third (Fig. 2E). During the interim period until the definitive restoration is fabricated, the grooves can be covered with white gutta percha (DeTrey Dentsply).

For metal resin-bonded FDPs, noble or base metal alloys can be used. They should be waxed on investment casts to facilitate the casting of the thin pins and grooves. While with noble

alloys the conventional ceramic firing process can be applied, base metal alloys allow for thinner retainers and smaller connectors because of their higher elastic modulus but necessitate the use of a gold layer to cover the dark oxide surface before ceramic veneering. Early studies documented reduced survival rates for resin-bonded FDPs of 88% after 5 years and loss of retention in 19% of the restorations.[17] A retentive preparation provided better results than the nonretentive design, with a survival rate of 95% after 10 years.[18,19]

Ceramic restorations are pressed or milled and made from lithium disilicate glass ceramics (IPS e.max Press; Ivoclar Vivadent), glass-infiltrated aluminum oxide (In-Ceram; Vita), or zirconia (LAVA; 3M ESPE). Since these materials do not allow the replication of thin grooves or pins, fixation relies solely on the adhesion of the resin cement to sound enamel (Fig. 3). The preparation involves removing undercuts with a slight proximal wrap around, delineating a clear marginal demarcation line on the palatal surface and providing a cingulum rest to enable exact positioning during the cementation procedure. Palatal clearance of 0.7 mm is required for zirconia, and at least 1 mm for lithium disilicate. The requirement that the material of the attachment (wing) be sufficiently thick may interfere with the need for sound enamel structure along the entire lingual surface, since only 0.5-mm enamel thickness is present in this area[20] and adhesion to dentin is reduced.[21] Based on this discrepancy between space requirements and the need for intact enamel, a deep vertical overlap may contraindicate ceramic retainers, while metal, particularly base metal alloys, can be thinner (0.3 to 0.5 mm). The indication for lithium disilicate is restricted to anterior tooth replacement because of its limited fracture resistance and the required dimensions of the connector, which should be at least 8 to10 mm^2. For zirconia resin-bonded FDPs, a connector surface of 6 to 8 mm^2 has been recommended. While 2-wing ceramic resin-bonded FDPs (In-Ceram) had a survival rate of 74% at 10 years, 94% survival was

achieved with 1-wing restorations.[14] Failures with 2-wing restorations were related to fractures in the connector region at one side, and restorations were kept as 1-wing resin-bonded FDPs.[14] To avoid excessive loading of the lever arm in 1-wing restorations, occlusal and functional contacts at the cantilever should be minimized. Ceramic chipping, but no fractures or debonding, have been reported with lithium disilicate 1-wing resin-bonded FDPs, which were mainly inserted in the anterior region with large connector sizes of 16 mm^2.[22] With zirconia 1-wing resin-bonded FDPs, early debonding occurred in 2 out of 15 restorations. These were successfully recemented, and the survival rate was 100% after 4 years (mean 53 months).[23]

CEMENTATION OF RESIN-BONDED FDPs

The improvements in long-term results with resin-bonded FDPs are mainly related to new cementation techniques. The adhesion obtained relies both on micromechanical retention and on chemical interactions of specific monomers (preferably phosphate monomers in Panavia F2.0; Kuraray, or RelyX; 3M ESPE) with the bonding substrate (Table III). On the tooth surface, optimal mechanical retention can be achieved following etching of the enamel surface with phosphoric acid (35% to 37%, for 30 to 60 sec), and any subsequent contact with saliva must be avoided. If zirconia or alloys are used, the restoration surface requires roughening by airborne-particle abrasion. Tribochemical silica-coating provides the most durable results and is applied either chairside (for example CoJet; 3M ESPE) or with the corresponding laboratory facilities (Rocatec soft; 3M ESPE). Airborne-particle abrasion with 30-µm silica-coated aluminum oxide particles creates a silica layer on the restoration surface and facilitates a chemical bond to the resin cement through the corresponding silane-containing primer.[24-26] For high noble alloys lacking a superficial layer of metal oxides, either silica-coating with silane primers or

conventional airborne abrasion in combination with specific metal primers is applied (Table III).[27] The polycrystalline ceramic zirconia is free of silica and adheres less well to resin-based cements than its glass ceramic or metallic framework counterparts.[28] With lithium disilicate ceramics, the microretentive surface is achieved by etching with hydrofluoric acid (HF), which selectively removes the glass matrix and exposes the crystalline ceramic structure.

After accomplishing the microretentive surface on the inner aspects of the attachments, the resin-bonded FDP is cleaned with water spray or in an ultrasonic bath and dried with pressurized air. As final conditioning, the corresponding primer is applied to the restoration and to the etched enamel surface (Table III). To cement metal restorations, opaque luting cements are selected to avoid any gray shine through and discoloration. If the interface on the labial aspect is still slightly visible after cementation, a thin layer of composite resin can be applied after cement excess has been removed and the surface again etched and bonded as for a conventional direct composite restoration (Fig. 2C).

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Table I Treatment strategy for anterior maxillary tooth loss according to patient's age

Age period (years)	Treatment option	Indications	Remarks
6-8	• autotransplantation of deciduous mandibular canine	- when space should be maintained and continuing growth of bone and soft tissue ensured	- if autotransplantation is postponed, early extraction of adjacent deciduous teeth may be required to enable orthograde eruption of adjacent permanent teeth
≥9	• autotransplantation of permanent premolars	- when space should be maintained and continuing growth of bone and soft tissue ensured	for adequate tooth selection evaluate: - residual dentition (potential aplasia or expected crowding) - root anatomy of premolars
≥11	• orthodontic space closure and recontouring of mesialized tooth form (for example using direct composite restorations): - symmetric on both sides (for example with both central incisors missing) - asymmetric on affected side (but keep midline) - anterior space closure and space opening in premolar region for single-tooth implant at age 20 (risk of infraposition is less critical in premolar regions)	- in patients with a convex profile and protruded incisors that have to be inclined lingually - with light color of canines, which are moved mesially into position of lateral incisors - with similar tooth widths of central and lateral incisors (wide lateral and small central incisors) - with aplasia of premolars or retrognathic maxilla (when reduction of arch circumference is not indicated)	during orthodontics denture tooth can be fixed in multiband appliance and subsequently reduced; instead of canine-protected occlusion, anterior group function has to be established;
	• short-term interim restoration performed chairside and adhesively fixed at mesial or distal, or both adjacent teeth, or indirect with coarse metal reinforcement (Rochette type), or as fiber-reinforced composite resin-bonded restorations	- as interim solution if autotransplantation is not feasible and space should be maintained	use coronal tooth portion of extracted tooth, denture tooth or composite build-up in combination with glass-fiber reinforcement
≥14	• resin-bonded FDP 1-wing	- as short- or long-term interim prosthesis	possibly requires retreatment due to maturation of soft tissues with physiologic recession of gingival margin reaching to cemento-enamel junction at adjacent teeth
≥16	• resin-bonded FDP 1- or 2-wings	- as short- or long-term interim prosthesis	possibly requires retreatment
≥20	• conventional FDP, or	- with root-canal treated abutment teeth; - with decreased space width and refusal of orthodontic re-alignment	enables changes in form, contour, and color of abutment teeth

≥25	• cantilevered single crown • single tooth implant	postponed in women and patients with long face type

Table II Options and indications for 1-wing and 2-wing metal or ceramic adhesive fixed dental prostheses

Location	Number of pontics/ teeth to be replaced	Number of abutments (1-/2-wings)	Material	Indications
anterior	1	1	ceramics	short- or long-term
			metal	long-term, with little intermax. Space
		2	metal	when splinting required, long-term
	2	2 or 2× 1-wing	metal ceramic	stable splinting, long-term
	3-4	2	metal	mandibular central incisors
posterior	1	2	metal	
			zirconia	not routinely

ceramics: lithium disilicate or zirconia

Table III Cementation of metal or ceramic adhesive fixed dental prostheses

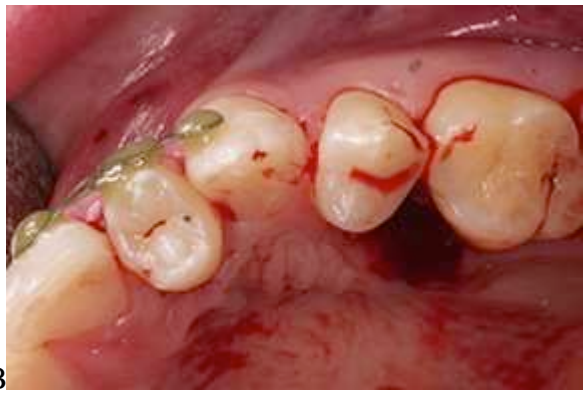
Restoration material	**Resin cement**	**Cleaning/ microretention at restoration (after try-in)**	**Conditioning of restoration**	**Intraoral micro-retention**	**Enamel conditioning**
general procedure (irrespective of material)	*polymerization process is initiated by blue light, for example, Panavia requires protection from oxygen exposure by glycerine gel for anaerobic curing*	*cleaning and degreasing (chloroform, isopropanol) after definitve evaluation, surface roughening, and modification, water spray or ultrasonic bath and air dry*	*primer*	*enamel etching (phosphoric acid 37%, 60 sec)*	*primer*
Zirconia or nonprecious alloys (chrom-moly)	MDP* containing resin cement (for example Panavia F 2.0, Rely X Ultimate)	airborne-particle abrasion with alumina particles coated with silica (for example CoJet 30 µm or SilJet 30 µm)	ceramic primer containing MDP monomer and silane coupling agent (for example Clearfil Ceramic Primer, Scotchbond Universal Adhesive)		bonding agent (for example ED Primer II, Scotchbond Universal Adhesive)
lithium disilicate glass ceramics (etchable)	MDP containing resin cement (for example Panavia F 2.0, Rely X Ultimate) or conventional bis-GMA-based resin cement (for example Variolink II)	hydrofluoric etching (for example 5% HF, 20 sec)	silane coupling agent (for example Clearfil Ceramic Primer, Scotchbond Universal Adhesive, Monobond Plus)		bonding agent (for example ED Primer II, Scotchbond Universal Adhesive, Syntac Classic)
high noble alloys	MDP containing resin cement (for example Panavia F 2.0, Rely X Ultimate)	Airborne-particle abrasion with alumina particles coated with silica (for example CoJet 30 µm or SilJet 30 µm)	silane coupling agent (for example Clearfil Ceramic Primer, Scotchbond Universal Adhesive, Monobond Plus)		bonding agent (for example ED Primer II, Scotchbond Universal Adhesive)
		airborne-particle abrasion with Al_2O_3	metal primer (for example Alloy Primer) containing thiophosphoric methacrylates		
fiber-reinforced composites	MDP containing resin cement (for example Panavia F 2.0, Rely X Ultimate), or conventional bis-GMA-based resin	Airborne-particle abrasion with alumina particles coated with silica (for example CoJet 30 µm or SilJet 30 µm)	silane coupling agent (for example Clearfil Ceramic Primer, Scotchbond Universal Adhesive,		bonding agent (for example ED Primer II, Scotchbond Universal Adhesive, Syntac Classic)

cement (for example Variolink II)	Monobond Plus)

*MDP: 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) creating covalent bond between the crystalline ceramics and the resin cement

LEGENDS

Fig. 1. A, 17-year-old adolescent with left lateral incisor in need of extraction due to external root resorption 4 years after trauma. Second premolar is in palatal position. B, Clinical situation after extraction of lateral incisor and autotransplantation of second premolar. Tooth had been adjusted mesiodistally to fit into recipient bed and has been splinted to adjacent teeth. C, Clinical situation following root canal treatment and direct restoration with composite filling material. D, Radiograph 4 years after autotransplantation.

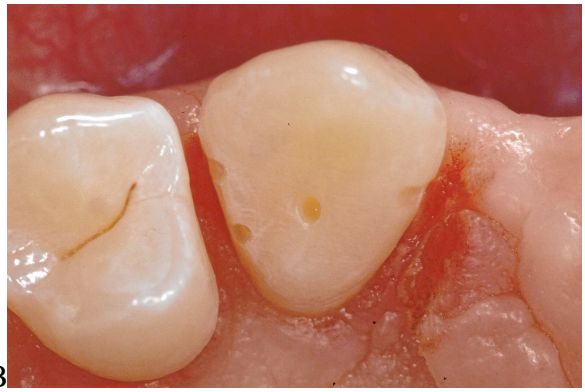
A  B 

C  D 

Fig. 2. A. Diagnostic preparation in a 16-year-old adolescent for metal resin-bonded retainer because of limited intermaxillary space. Adjacent canine selected as abutment tooth with

intraoral parallelometer mounted on diagnostic cast. B, Preparation with vertical grooves ending palatal of incisal edge and providing tooth engagement buccolingually; marginal gingivectomy for exposure of entire enamel area. C, One-wing resin-bonded fixed dental prosthesis luted with opaque cement; distally composite resin was added. D, Buccal view after 8 years. E, Palatal view at 8-year recall.

A 

B 

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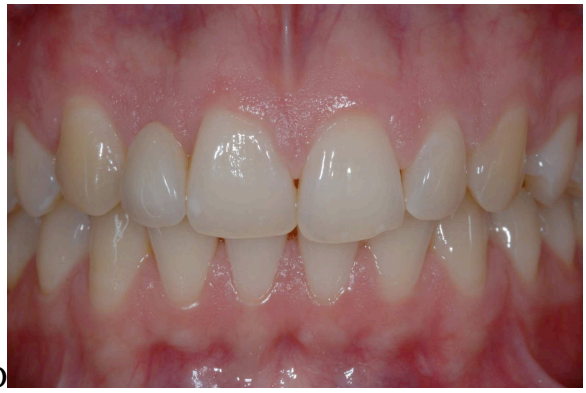
D 

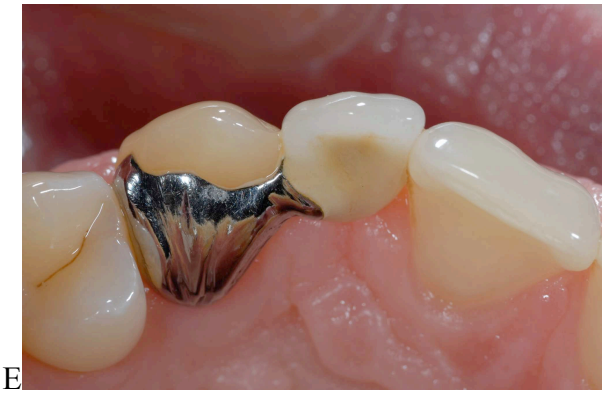
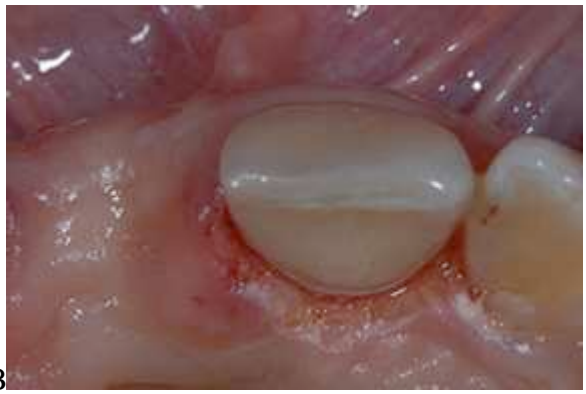
E 

Fig. 3. A, 18-year-old woman with edentulous space after traumatic loss of right central incisor (situation 6 weeks after connective tissue grafting in pontic region). B, Minimally invasive preparation within palatal enamel layer. C, Resin-bonded FDP (lithium disilicate) with 1 wing cemented. D, Palatal aspect, occlusal, and functional contacts avoided.

A  B 

C  D 

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